

Report for 2003OR30B: Development of a relationship between water quality data and land use in the Oak Creek Watershed

- Articles in Refereed Scientific Journals:
 - Poor, C., K.Vache, D.Godwin, J. Bennett, C. Blatchford, M. Cox, M. Dewey, F. Kizito, J. Melick, R. Mitchell, J. Mutti, J. Nicholas, L. Parker, J. Pennington, J. Schmalenberg, Spelts, J. McDonnell, Improvement of Process Description in Conceptual Runoff Models in the Ungauged Basins: A Case Study of Landuse Effects on Water Quality, EOS Trans. AGU, 85(17), Jt. Assem. Suppl., Abstract H53B-04.
- Other Publications:
 - Poor, C., J. McDonnell, P. Nelson, The Effects of Land Use on Nitrate and DOC Dynamics in a Mesoscale Watershed (in progress).

Report Follows

Problem and Research Objectives: The Oak Creek Watershed is 33 km², and is located in Corvallis, Oregon. Oregon State University (OSU) manages approximately 40% of the watershed, with multiple uses including forestry, agricultural animal production, stadiums, and urban campus activities. It was determined in 1999 that these multiple uses are not managed in a coordinated manner. To minimize non-point source pollution and properly use public resources, coordination of management objectives and operations is essential. An Oak Creek Action Team was appointed in 1999 to determine key issues and recommend alternatives for Oregon State University.

The Oak Creek Action Team issued a report in June 2000 recommending additional monitoring and management actions to improve the health of Oak Creek and benefit the research and teaching activities in the watershed. This project will provide additional water quality data for the watershed and recommend management improvements, which will carry forward the Action Team's plan. The overall result of this project will be improved management (and thus water quality) and further development of the watershed as a research and teaching tool for OSU.

The objectives of this project are to establish baseline water quality data, to relate land use with water quality, and to recommend land use management improvements for the Oak Creek Watershed. Specific objectives include:

1. Process synoptic water quality samples taken in October 2002 to determine water quality parameters.
2. Analyze water quality data from November 2001 and October 2002 synoptic sampling to determine the seasonal baseline water quality conditions (spatially/longitudinally) in the watershed.
3. Develop a detailed temporal relationship between land use and water quality using baseline water quality and storm events.

Methods, Procedures, and Facilities: Methods for completing the project are summarized below:

1. Process synoptic water quality sampling conducted at 35 sites across the Oak Creek Watershed (Figure 1) in October, 2002 using the Environmental Engineering laboratory on the OSU campus. Specific constituents that will be determined are:
 - a. Nutrients (nitrate, ammonia, organic nitrogen, phosphate, organic phosphorous)
 - b. Electrical conductivity (EC), base cations (Ca^{2+} , Mg^{2+} , Na^+ , K^+) and major anions (HCO_3^- , SO_4^{2-} , Cl^-).
 - c. Oxygen isotopes (for water source determination). (Note: Oxygen isotopic analyses will be conducted in collaboration with USGS Water Quality Laboratory, Menlo Park, California.)
2. Compare the water quality data from the November 2001 and October 2002 synoptic sampling events. The November sampling was conducted when antecedent conditions were relatively wet after the first fall rains, but nevertheless during baseline runoff conditions not influenced by any recent storm events. The October sampling was conducted during baseline runoff flow when antecedent conditions were still relatively dry. Figure 1 shows the speciation and distribution of nitrogen in the watershed from the November 2001 sampling. A similar analysis will be conducted for the October 2002 sampling. We anticipate there will be differences between the water quality constituents from these two sampling dates. Areas that were hydrologically isolated during dry conditions may be connected to the stream when conditions become wet, creating new sources of water quality constituents. We hypothesize that concentrations of water quality constituents such as nitrate will be higher after the first few fall storms (November 2001 sampling) than during dry conditions (October 2002 sampling).
3. Collect water quality samples in four subcatchments of varying land uses (forested, agricultural, residential and suburban) during a fall, winter, and spring storm event to determine how nitrate and DOC concentrations vary during storm events. Sampling sites are shown in Figure 3.

4. Use all water quality data to determine how land use affects water quality in the Oak Creek Watershed. Determine sources and sinks of nutrients.
5. The information derived from this analysis will be tabulated and put on the existing Oak Creek website (<http://cwest.orst.edu/oakcreek/index.htm>) for use by managers and the general public.

Existing equipment in the Environmental Engineering laboratories at Oregon State University that will be used in support of the proposed research include a Dionex Model DX 500 Ion Chromatograph, Dohrmann DC-190 Total Organic Carbon Analyzer, Hewlett-Packard Model 8453 Scanning UV-Visible Spectrophotometer, and Varian Liberty 150 ICP Atomic Emission Spectrophotometer. Other instrumentation to be used includes specific ion meters, automatic titrimeters, and laminar flow hood. Fieldwork will be supported by portable instruments including a pH meter, conductivity meter, and turbidimeter. Supporting facilities on the O.S.U. campus with a wide range of analytical capabilities are available on a cooperative basis, including the Radiation Center (isotope preparation and counting), Soil Science Laboratory (soil chemical and physical characterization), Agricultural Chemistry Laboratory (pesticide and organic compound analyses), Forest Sciences Laboratory (trace nutrients), and Oceanography Laboratory (ICP-MS for trace metals).

Principal Findings and Significance: Table 1 shows the average concentrations from the synoptic sampling in 2001 and 2002. In general, nitrate and sulfate concentrations are higher during the November 2001 sampling event (wet antecedent conditions). This may be due to the rising water table flushing these nutrients out of the soil during the wetting up sequence in the fall. The October 2002 sampling event occurred after the summer dry period, and thus most of the stream water is likely from groundwater. Magnesium, silica, DOC, and chloride concentrations were similar for both events. Excluding DOC, these ions are considered conservative, and therefore are not expected to change significantly. Calcium concentrations are lower during the November 2001 event, indicating there may be a dilution effect for this cation. Calcium concentrations in the groundwater may be higher, with soil water decreasing stream water concentrations when wet conditions occur.

Table 1. Average Values of Water Quality Concentrations

Date	calcium (mg/L)	magnesium (mg/L)	silica (mg/L)	DOC (mg/L as C)	chloride (mg/L)	nitrate-N (mg/L)	sulfate (mg/L)
October 2002	13.07362169	9.571983601	12.2592558	4.137051624	9.280862974	0.07148621	2.544722558
November 2001	10.29419934	8.772846957	12.1406596	3.721383705	8.967357209	0.516998524	7.762547234

To further investigate water quality in the Oak Creek Watershed, three storm events were sampled in subcatchments with four different land uses. For all storms, chloride concentrations were constant except for the suburban catchment. Figure 4 shows the general trend of chloride concentrations for the suburban catchment, which was seen for the three storm events. Constant chloride concentrations indicate that the sources of chloride in the catchment have similar concentrations. In the suburban catchment, chloride concentrations initially decrease on the rising limb of the hydrograph and then increase. This “dip” in chloride concentrations may be due to the altered nature of this catchment; storm water is routed to storm pipes that empty into Oak Creek. Thus there is a disconnect between the soil and storm water. The decrease in chloride concentrations could be due to the direct runoff of storm water, with the soil eventually wetting up and contributing to runoff. Nitrate concentrations showed a similar trend in the suburban catchment.

Both the forested and residential nitrate concentrations increased with the increase in flow for each storm. This indicates there is an unlimited source of nitrate that is not being diluted with rain water. Nitrate concentrations are shown in Figure 5 for the forested catchment. In the agricultural catchment, nitrate concentrations decreased with increasing flow for the fall (Figure 6) and winter storms, but increased with increasing flow for the spring storm (Figure 7). This may be due to an additional source during the spring; this storm event was right after the lambing period and a high density of sheep were grazing within the watershed. There were also cows grazing within the watershed that were not present during the fall and winter storms.

In general, the suburban catchment had the highest nitrate levels (~1.5 mg/L as N), followed by the residential and agricultural catchments (both ~0.2 mg/L as N), and the forested catchment (~0.04 mg/L as

N). This follows the general assumption that nitrate concentrations will increase with increasing development. Chloride concentrations also generally increased with increasing development, with the residential catchment having the highest chloride concentrations (~14 mg/L). DOC concentrations were similar for the forested, agricultural, residential, and suburban catchments. This is due to the abundant source of organic carbon (natural or landscape) in each catchment.

From this data, it appears that nitrate is strongly controlled by the hydrology of the catchment. Depending on the availability of sources, nitrate will either increase with increasing flow or be diluted by rain water. More work is needed to determine sources and timing of inputs. It is also apparent that land use affects nitrate concentrations. As development increases and the stream flow paths become increasingly disconnected with the soil, removal mechanisms such as denitrification are no longer occurring. Large riparian zones may help eliminate nitrate contamination to streams; if water flows through a riparian zone before it reaches the stream, nitrate concentrations will decrease. Since the natural stream no longer exists and a pipe drains the catchment, treatment of the storm water draining from the suburban catchment may be needed for this to occur.

Student Support (# and degree level): One PhD student (Cara Poor) was funded with this support.

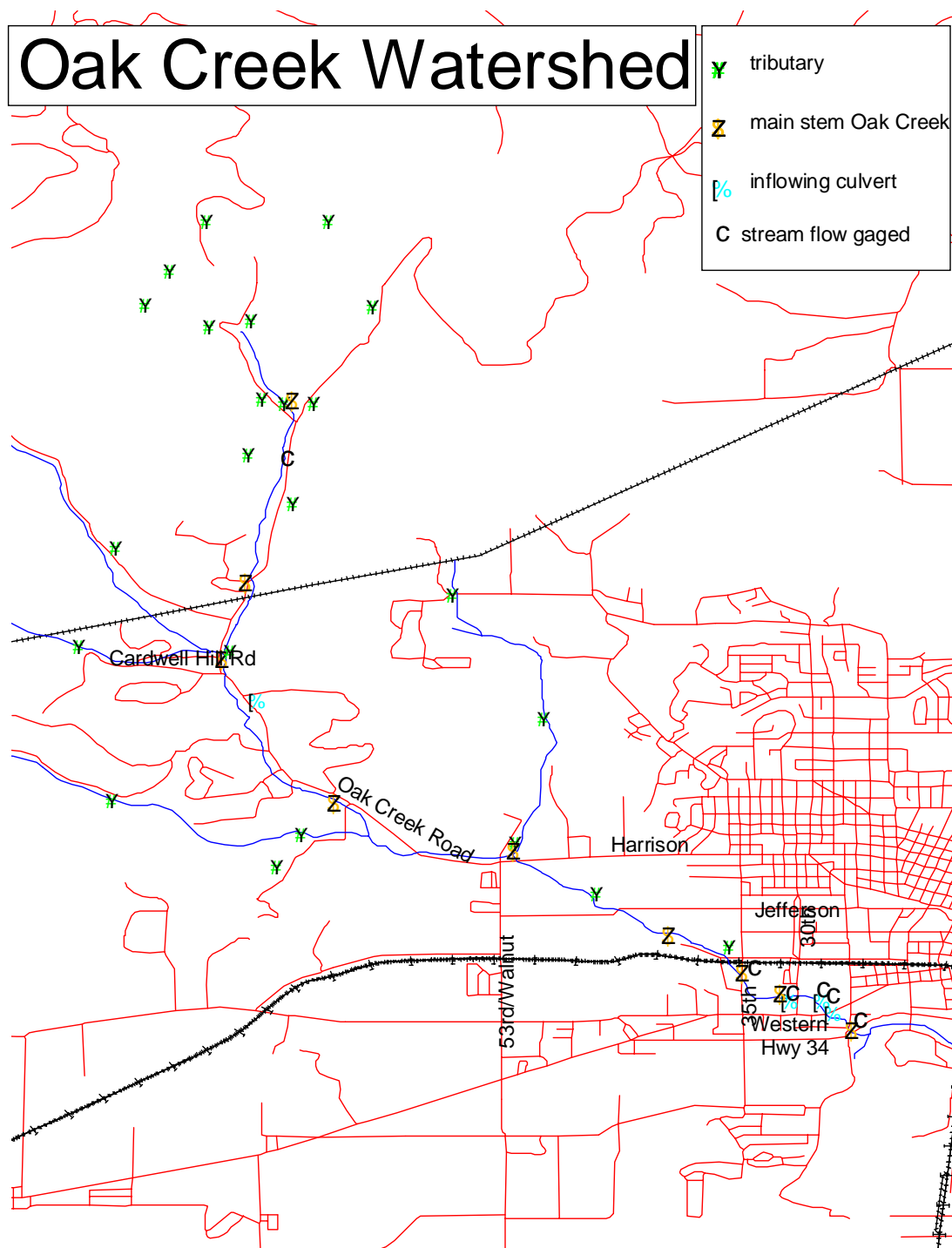


Figure 1. Locations of synoptic water quality samples, taken in November 2001 and October 2002.

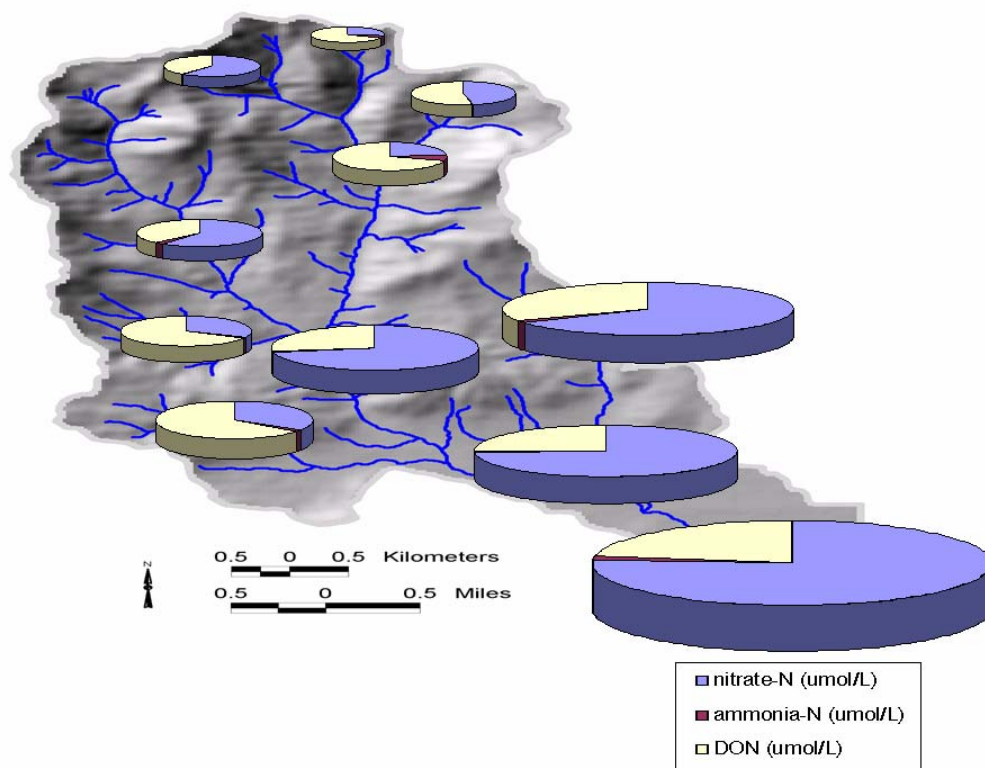


Figure 2. Results from November 2001 synoptic sampling. Pie charts are scaled to total nitrogen concentrations.

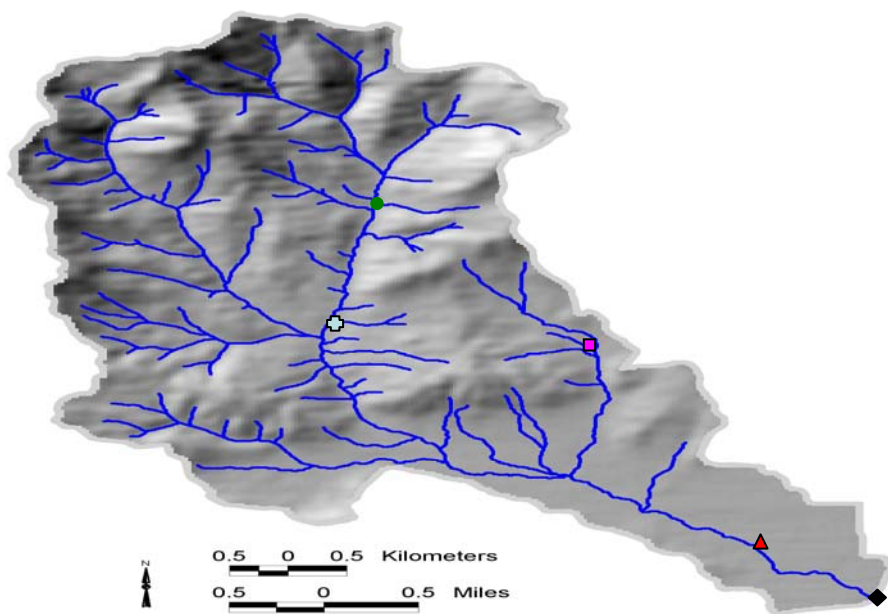


Figure 3. Storm Sampling Sites within the Oak Creek Watershed.

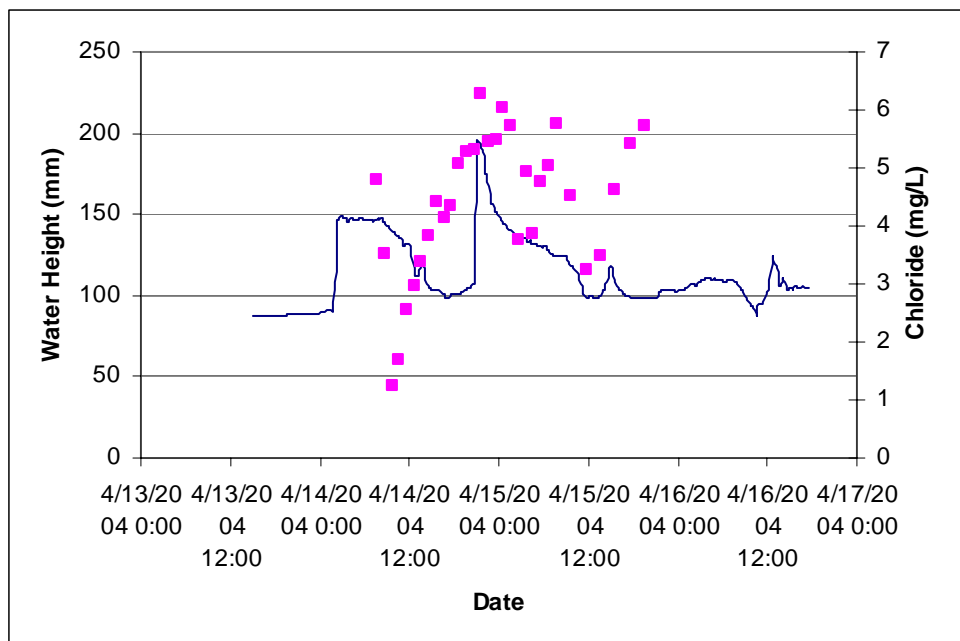


Figure 4. Chloride Concentrations in Suburban Catchment during the Spring Storm Event.

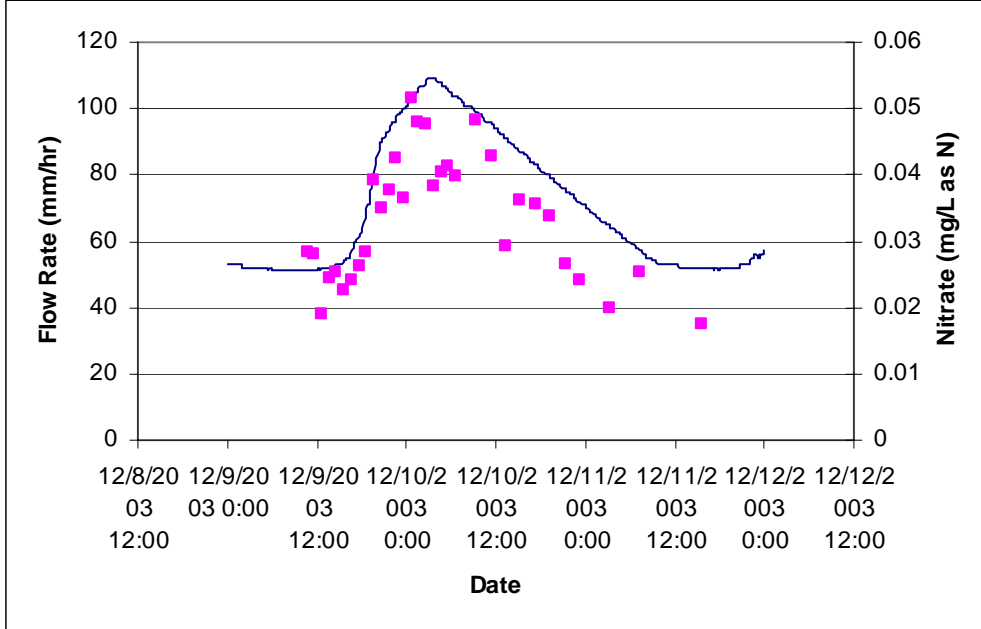


Figure 5. Nitrate Concentrations in the Forested Catchment during the Fall Storm Event.

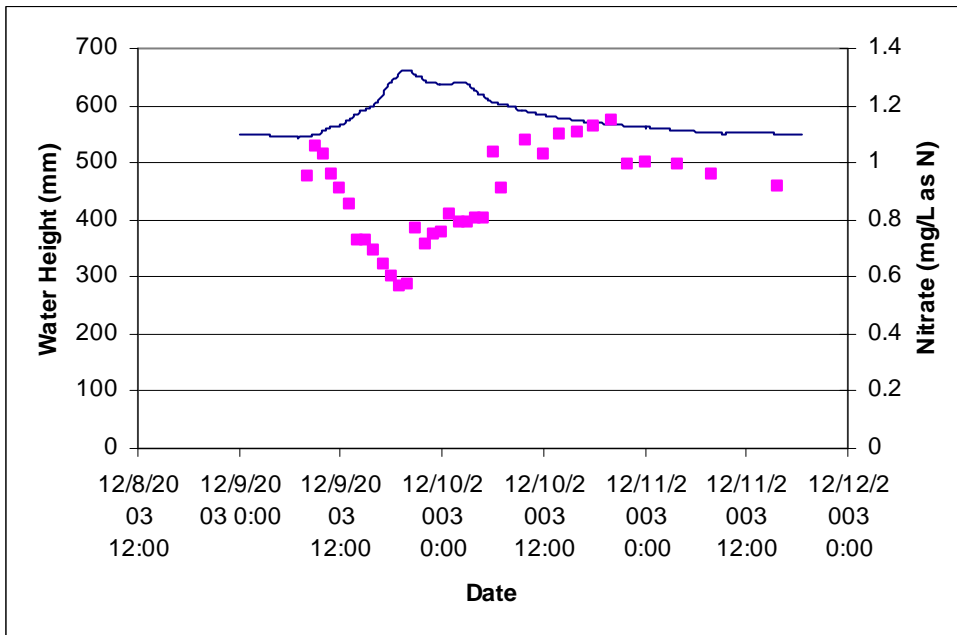


Figure 6. Nitrate Concentrations in the Agricultural Catchment during the Fall Storm Event.

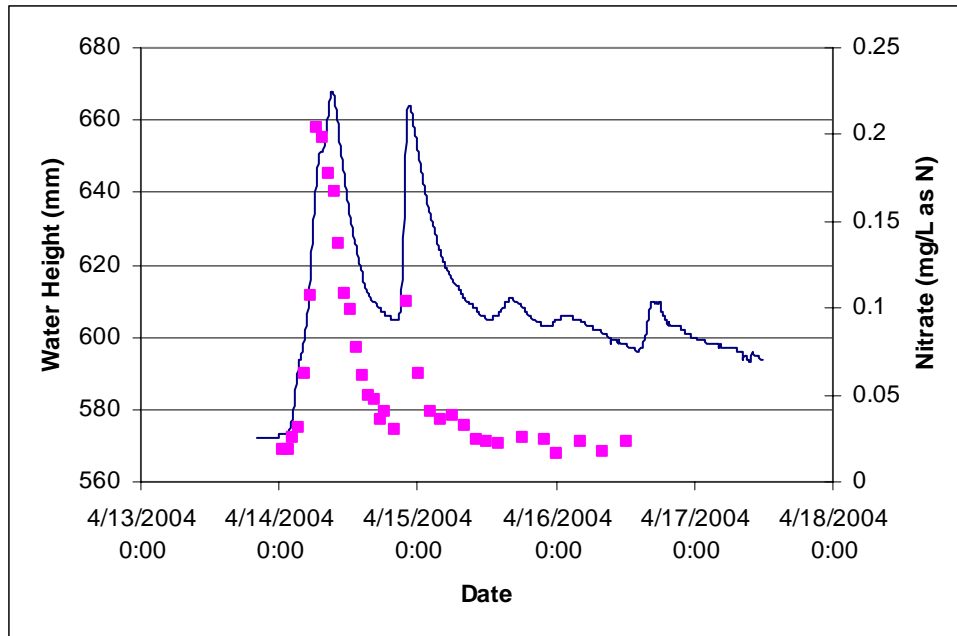


Figure 7. Nitrate Concentrations in the Agricultural Catchment during the Spring Storm Event.